Educational Attainment and Timing of Fertility Decisions*

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Abstract

This paper focuses on timing of fertility decisions, conditional on the level of educational attainment of parents. Timing of fertility and educational attainment of parents rationalize the negative relationship observed in the data between hourly wages and childbearing. It is shown how the recent evolution in total fertility rates observed in developed countries could be in part the result of a transition from an early childbearing regime to a late childbearing regime. I develop a general equilibrium overlapping generations model in order to understand the joint determination of timing of childbearing decisions together with other household economic decisions in a life cycle framework. I show how idiosyncratic uncertainty might have asymmetric effects on completed fertility depending on timing of childbearing, generating the differences in completed fertility observed between households that differ in their level of educational attainment.

Keywords: Childbearing, Overlapping Generations, Idiosyncratic Uncertainty.

JEL Classification: D1, I12, J1.

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1 Introduction

This paper focuses on the implications of the level of educational attainment of households for the timing of fertility decisions. Differences in educational attainment generate differences in the age profile of labor earnings of households, both in terms of the level of hourly wages and its shape over the life cycle, affecting timing of fertility decisions. It is shown how changes in timing of fertility decisions (as a result of increasing female's access to higher education) can partially account for the recent evolution in total fertility rates observed in developed countries. I study, in a cross-section of households, the relationship between timing of childbearing and other economic variables, and also the differences in timing depending on the level of educational attainment of parents. I develop a general equilibrium overlapping generations model in order to understand the joint determination of timing of childbearing decisions together with other household economic decisions in a life cycle framework.

In the model economy proposed, idiosyncratic uncertainty has asymmetric effects on completed fertility depending on timing of childbearing, generating the differences in completed fertility observed between households that differ in their level of educational attainment. In this respect my approach departs from traditional explanations in the literature of the negative relationship between earnings and completed fertility.

Period Total Fertility Rate (TFR) is measured as the "total lifetime number of births that would be predicted if a representative woman realized the age-specific fertility rates that prevailed in a particular year" (Hotz et al. (1997)). On the other hand, completed fertility refers to the total number of children a woman has had during her entire fertile age. Absent changes in timing of fertility these two measures coincide. However, TFRs might be misleading in an environment where there are changes in timing of fertility decisions. This point is also discussed in Bongaarts (1999). Thus, part of the recent evolution of TFRs in developed countries might be understood as the result of a transition from an early childbearing regime to a late childbearing regime.

An increase in level of educational attainment has both a permanent and a transitory negative effect on TFRs. Highly educated females have on average less completed fertility. This is the permanent effect. Moreover, due to differences in timing (highly educated females have children later on average) there is an additional transitory decrease in TFRs. Therefore, in a period of rapid increase in levels of educational attainment of females one would expect TFRs to drop below their future stable level once the transition is completed.

Therefore, my objective is to understand how the level of educational attainment of parents determines age-speci…c birth rates, i.e. timing of fertility decisions and completed fertilities.

The analysis of a cross section of households in the Panel Study of Income Dynamics (PSID) displays the following stylized facts:

1. Among the younger households (20-29 years old), those who have had newborns in the last two years have, on average, lower income, due to the fact that they work less hours and not to the fact that wages di¤er substantially.

2. Among the older households (30-39 years old), those who have had newborns in the last two years have, on average, higher income, even though they work less hours, given that their wages are substantially higher. Moreover, the decrease in hours worked due to parenthood is smaller than for younger households.

3. Younger households that have had newborns in the last two years have, on average, lower level of educational attainment, while the reverse is true for older households. Thus, parents with no college education have children earlier on average, while college educated parents delay their decision of having children.

4. The relationship between wages and childbearing is slightly positive (if not zero) once we condition for age of the female in the household.

This …ndings are consistent with the observation, as reported in Simon (1977), that fertility is positively related to earnings once we control for age and educational groups. The …ndings of Wolpin (1984) also imply a slightly positive relationship between income and completed fertility and a negative e¤ect of education of females on completed fertility.

Consequently, I construct a model that is capable of generating age-pro…les of childbearing depending on educational status similar to those observed in the data and ask the following question: is the model consistent with facts 1 to 4? The answer is yes, validating the model along the dimensions of interest.

The model proposed is a general equilibrium overlapping generations model with idiosyncratic uncertainty with respect to hourly labor earnings. In presence of incomplete financial markets uncertainty generates a nontrivial distribution of wealth and income within age cohorts, allowing the study of the interaction between educational attainment of parents, age, wage/income status and timing of fertility decisions. Moreover, the assumption of incomplete markets and borrowing constraints on households is what generates a non-trivial relationship between current wages and childbearing decisions, given that households are not allowed to borrow on their future income. Notice that the relationship between income and fertility might be misleading, provided that hours worked are treated as endogenous. In this environment timing of fertility decisions are explicitly addressed, in the sense that childbearing is modelled as a sequential binary decision.

In the literature the negative relationship between wages/income and completed fertility has been explained by the quantity-quality trade-off and the analysis of the time allocation of households. The quantity-quality trade-off approach, pioneered by Becker (1960), is the first attempt to account for the negative relationship between income and completed fertility by modelling preferences in which parents value not only the quantity but also the quality of children. In this framework higher income would be associated with lower quantity but higher quality of children, and therefore higher hourly wages would imply less completed fertility.

An alternative exploration to account for the negative relationship of income and number of children is the analysis of time allocation treating childcare as a time intensive activity. This approach follows Mincer (1963), Becker (1965) and Willis (1973); and the relationship between fertility and female labor supply has been extensively studied in the literature. For example, Rosenzweig and Wolpin (1980) or Moffitt (1984) build and estimate models of life cycle labor supply and fertility; see Browning (1992) or Hotz et al. (1997) for surveys of this literature. Again, the argument implies that higher wages are associated with lower fertility.

However, in the model proposed the only reason why highly educated households have less children than low educated ones is the asymmetric effect of earnings uncertainty due to differences in timing. The key for this asymmetry to arise is that children in the environment proposed are treated as an irreversible consumption durable.

The model can be parameterized to match the differences in completed fertility depending on educational levels found in the empirical evidence.

The paper is organized as follows. Section 2 discusses the empirical evidence. Section 3 presents the model. Section 4 discusses the computation and parameterization of the model. Section 5 discusses the results and compares them with the empirical evidence and Section 6 concludes.

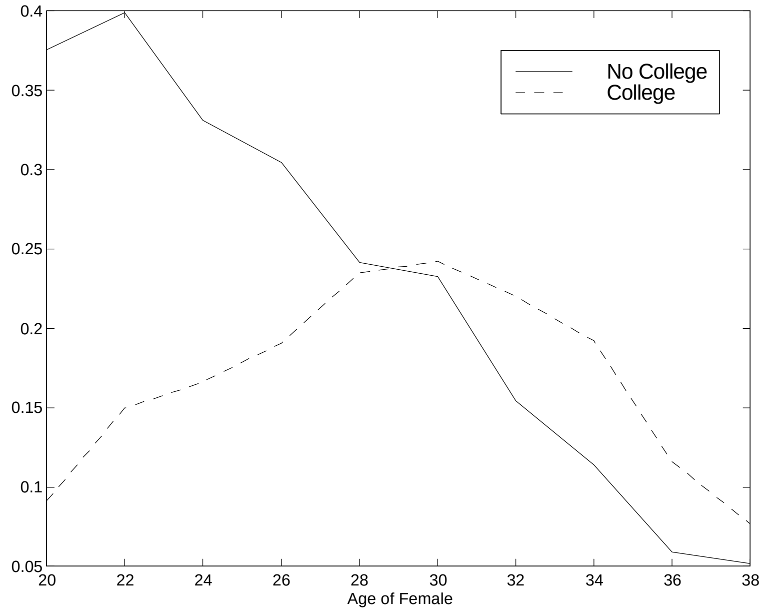
2 Empirical evidence

This section reports evidence on the differences in timing of childbearing depending of level of educational attainment of females, the recent evolution of TFRs in some developed countries and the relationship between income, wages, hours worked and childbearing. Different sources have been used and are specified in every case. This section shows and discusses the empirical facts 1 to 4 mentioned in the introduction.

2.1 The role of education in fertility

Highly educated females have less children on average and they have them later. I will use the Current Population Survey (Fertility and Marital Status Supplement) of January 1994 in order to compute age-education specific birth rates. The whole female population is divided in two groups, those with some college education or more and those without any college education. Figure 1 reports the age-education birth rates. Notice that I am choosing periods of two years and I am reporting results for the range of ages between 20 and 39, the reason for doing so is that it corresponds to the periods I will be using later in the model.

Figure 1: Age-Education Birth Rates



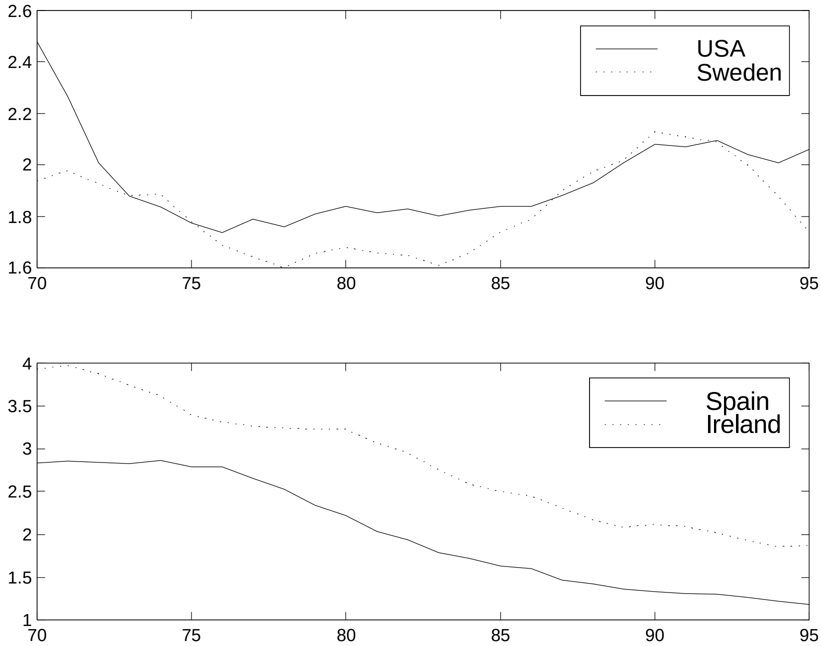
Completed fertility of non-college educated females of ages between 46 and 50 is 2:46 children, while the corresponding …gure for college educated females is 1:97. Notice that integrating the age pro…les of Figure 1 should yield exactly these completed fertility …gures, provided that age-education birth rates were constant over time. Integrating the age-pro…les found in the cross section of households we get numbers that are very close to completed fertilities, 2:56 for non-college females and 1:95 for college ones.

2.2 Recent evolution of total fertility rates

Figure 2 displays the evolution of TFRs for some representative OECD countries.[1] Over the period 1970-95 TFRs in countries like Spain, Greece, Italy or Ireland have been continuously decreasing. In Spain TFRs continuously decreased from 2:84 in 1970 to 1:18 in 1995, 2:43 to 1:17 in Italy, 3:93 to 1:87 in Ireland and 2:34 to 1:35 in Greece.

[1] I thank Pedro Mira for providing me with these numbers. Ahn and Mira (1999) study the relationship between the evolution of TFRs and female employment rates.

Figure 2: Evolution of TFRs in Selected Countries



This process of decreasing TFRs has been simultaneous to a progressive and continuous increase in the level of educational attainment of females. In Spain, in 1960 2% of females between ages 18 and 24 were (or had been) enrolled in higher education, while this figure continuously increased until 25% in 1990. In 1970 this figure was still 10%, below that of the USA a decade before (13% in 1960).

However, in the USA, as well as in the Scandinavian countries, TFRs decreased substantially between 1970 and 1980, but started increasing afterwards, specially in the second half of the eighties. TFRs stabilized in the USA slightly over 2 during the first half of the nineties, below its 1970 level. The level of educational attainment of females increased substantially in the USA between 1960 and 1990, but it has been stable since with a ratio of 45% of college attendance (the highest in OECD countries).

Thus, Spain has experienced a rapid and continuous increase in college attendance of females in the last 20 years. Moreover, this fast increase is quantitatively comparable to the one that the USA experienced at a more moderate pace from 1960 until the early 1990's.

Developed countries have experienced a transition from an early childbearing regime to a late childbearing regime, due to the increase in female's access to higher education. Bongaarts (1999) discusses the implications of changes in timing for the evolution of TFRs, even though he does not directly relate changes in timing to changes in educational attainment of females.

Period t TFR is measured using the age-specific birth rates as follows:

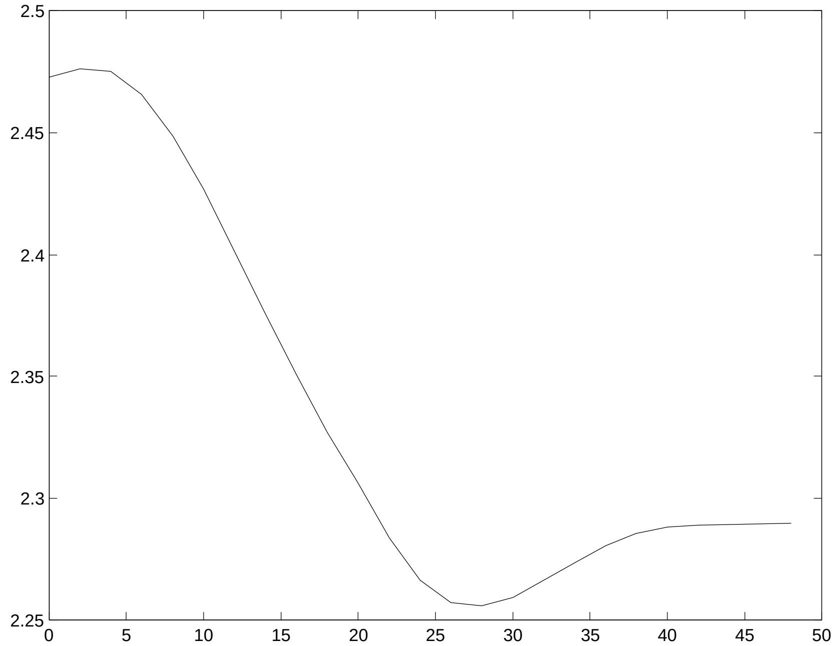
$$TFR_t = \sum_{a=15}^{44} BR_{t;a}$$

where $BR_{t;a}$ represents the period t age-specific birth rate of the age a cohort (number of births in period t from females with age a divided by number of females of age a). Therefore, the TFR in period t is the completed fertility that a representative female would have, provided that over her entire lifetime she would experience birth rates at every age as those observed in period t. However, during the transition from an early childbearing regime to a late childbearing regime TFRs might be much smaller than completed fertility.

In order to assess the role of changes in timing of childbearing in explaining the evolution of TFRs I perform the following exercise, using the age-specific birth rates as reported in Figure 1. I assume that age-specific birth rates depending on education are constant at the 1993 level, and compute the implied evolution of TFRs for an economy where over time the fraction of college educated young females is increasing. Specifically, I assume that the fraction of college educated females is increasing linearly from 10% to 45% over a 20 year period and stays constant afterwards.

The results of this exercise are displayed in Figure 3. Notice how this figure displays the main features of the evolution of TFRs as observed in developed countries like the USA or Sweden. TFR decreases continuously during the first 20 years, recuperating afterwards and stabilizing at a new level below its initial level. The final TFR is lower than the initial one because completed fertility of highly educated households is smaller.

Figure 3: The Role of Changes in Timing for Evolution of TFRs



In terms of understanding the evolution observed in countries like Spain, this picture illustrates how a transition from an early childbearing regime to a late childbearing regime could generate continuous and sizeable decreases in TFRs and one should expect that once the transition is over, TFRs should increase to their new stationary level, as observed for countries that experienced this transition at earlier stages (USA or Scandinavian countries).

Therefore, timing of fertility is an important aspect in order to understand the recent evolution of TFRs in developed countries. The question that arises now is: what determines timing of fertility decisions?

2.3 Income and fertility

I have used data on a cross section of households in 1993 from the Panel Study of Income Dynamics (PSID), in order to analyze jointly income, wages, level of educational attainment and the life cycle pattern of fertility and labor supply decisions. The reason to use PSID data is that this database is more comprehensive in terms of sources of income and hours worked of adult members of the household.

In the database there are 2,880 observations on households formed by a male and female adults such that the female's age is between 18 and 40 years old. Most of the results I will discuss apply to this subsample. The reason why I will mainly focus on male and female adult households is to avoid results being in‡uenced by single parenthood, even though the results are not a¤ected when using the whole sample regardless of household composition. This way we can compare the empirical evidence with the model results, that abstract from household composition e¤ects.

Throughout this analysis I will refer to the age of a household as the age of the female in the household.

Table I reports, for households formed by a male and female adults, the fraction of households within the given cohort that have had a newborn during the last two years,[2] together with average household income depending on whether they had a newborn or not during the last two years. The fraction of households with newborns is clearly decreasing in age. Notice also that for younger cohorts (20-24 and 25-29), those who have had newborns in the last two years have lower income than those who did not. However, for older cohorts (30-34 and 35-39) the reverse is true.

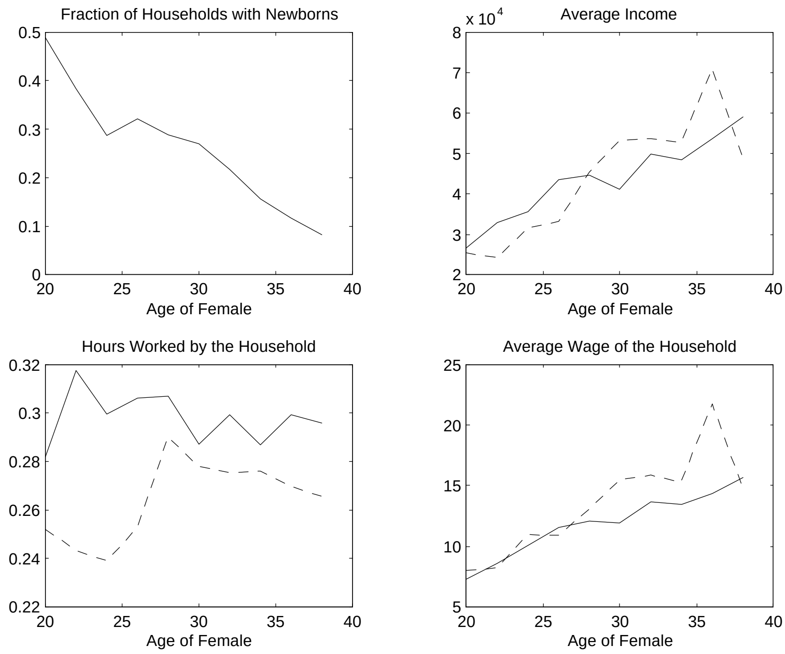
Table I: Newborns and Income

Cohort	Fraction with newb.	Income w/o newb.	Income with newb.
20 ¡ 24	0:39	32; 776	25; 464
25 ¡ 29	0:30	42; 492	38; 662
30 ¡ 34	0:23	46; 709	55; 011
35 ¡ 39	0:11	54; 733	55; 842

Figure 4 shows a more detailed analysis depending on age. The fraction of households that have had newborns in the last two years is clearly decreasing in age. Also, we observe that up to age 28 average income of those who decide to have newborns is smaller, while the reverse is true in general for households where the woman is older than 28.

[2] The fraction of households with newborns coincides with cohort-speci…c birth rates under the two following assumptions: childbearing cannot occur more than once in a two year period and there is only one child born.

Figure 4: Comparison of Households with and without Newborns
With Newborns - - - - - Without Newborns ———



In order to avoid problems of comparability I have excluded from Table I those households that are formed only by one female. Table II reports the same statistics for households formed by an adult woman alone. We observe that the fraction of households with newborns in the last two years is also decreasing in age. Again, within the youngest cohorts, those who have had newborns have lower average income, while this fact is reversed for cohort 30-34, but not for 35-39. In what follows I will focus exclusively on households formed by a male and female adults.

Table II: Female Only Households. Newborns and Income

Cohort	Fraction with newb.	Income w/o newb.	Income with newb.
20 ¡ 24	0:24	17757	8611
25 ¡ 29	0:16	17925	15011
30 ¡ 34	0:10	16950	18040
35 ¡ 39	0:10	21588	15773

Now, I address the issue of how the decision of having children is related to hours worked and wages depending on age. In Table III the …rst two columns refer to the male, with and without newborns respectively. The third and fourth columns refer to the female in the household. We observe that there is no signi…cant di¤erence in hours worked by males between those who have had newborns and those who do not. However, there is signi…cant di¤erence in the number of hours worked by the woman of the household.

Table III: Hours Worked

Cohort	Hours worked M w/o newb.	Hours worked M with newb.	Hours worked F w/o newb.	Hours worked F with newb.
20 ¡ 24	2; 064	1; 982	1; 322	791
25 ¡ 29	2; 031	2; 075	1; 393	897
30 ¡ 34	2; 023	2; 042	1; 237	1; 110
35 ¡ 39	2; 024	1; 974	1; 295	939

Figure 4 also reports hours worked by the household as a fraction of discretionary time.[3] Clearly, hours worked by households with newborns are smaller, and notice also that the gap between hours worked by households who have had newborns and those who did not is substantially bigger for younger households.

Table IV: Hourly Wages

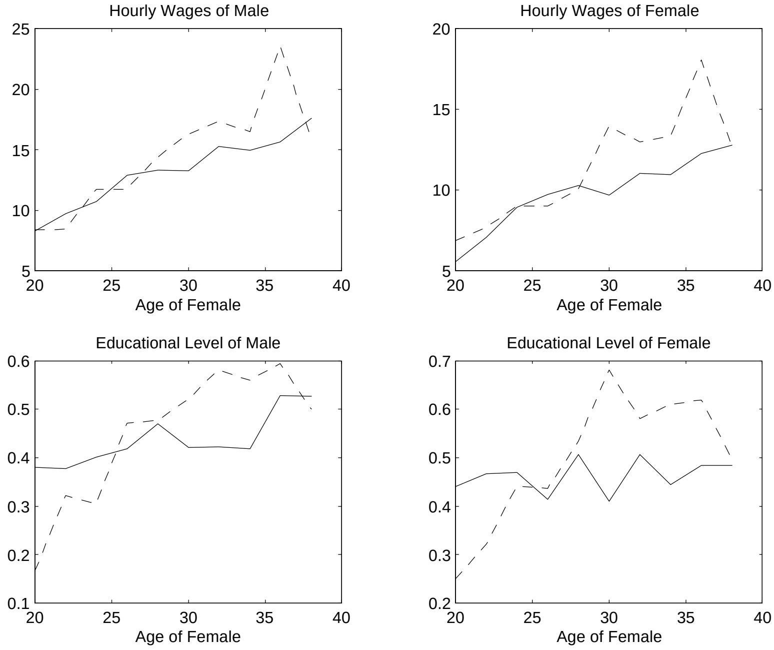
Cohort	Wage Male w/o newb.	Wage Male with newb.	Wage Female w/o newb.	Wage Female with newb.
20 ¡ 24	9:82	9:03	7:40	7:54
25 ¡ 29	12:66	13:04	9:84	9:60
30 ¡ 34	14:72	16:74	10:41	13:90
35 ¡ 39	16:15	19:38	12:33	14:17

According to Table IV, hourly wages are not signi…cantly di¤erent between those households with and without newborns for households younger than 30 years old. However, for households 30 years old or older hourly wages are substantially higher for both the male and the female in households with newborns. See Figure 4 for a more detailed age range analysis regarding the

[3] Assuming that discretionary time is 15 hours a day per adult, seven days a week, 52 weeks a year, we …nd a total time endowment of 10,920 hours per household. Average hours worked by household in the sample are 2,836, 26% of 10,920. This numbers are roughly consistent with the evidence that households allocate around 1/3 of their discretionary time to market activities, which is the standard value in the business cycle literature.

relationship between wages and childbearing as a function of age. Finally, notice in Figure 5 that the conclusions are not the e¤ect of considering average household wage, and these facts hold for both the male and female separately.

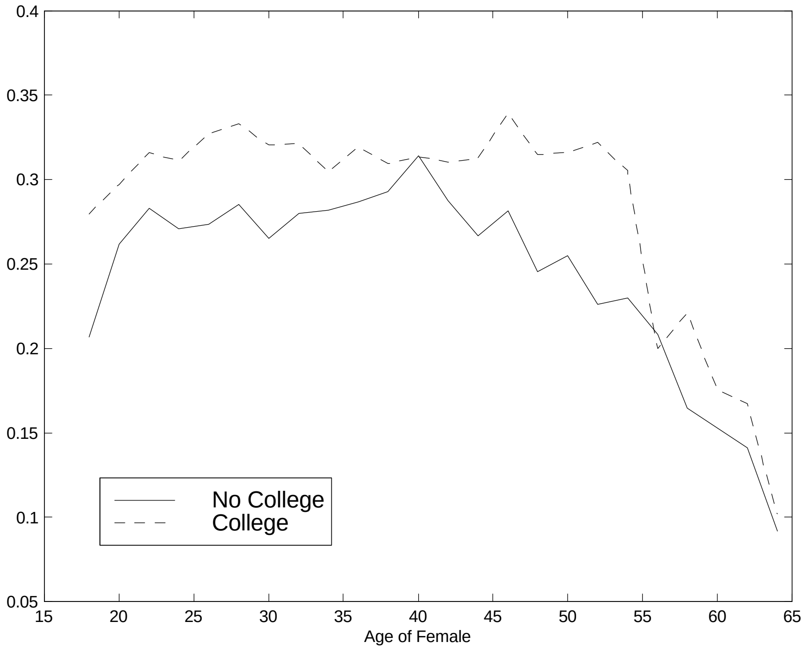
Figure 5: Wages and Education, with and without Newborns
With Newborns - - - - - Without Newborns ———



Hence, among younger households those who have newborns have lower income because they work less, not because they have lower wages than households without newborns. However, for older households, income of those who have newborns is higher, even though hours worked are less, because they have signi…cantly higher wages than households without newborns.

The relationship between hours worked and level of educational attainment is displayed in Figure 6. Yearly average hours worked by household are roughly constant between ages 20 and 45, with hours worked by college educated households being higher. On the average, yearly hours worked are 2;657 for non-college educated households and 3;106 for college-educated households. Notice also how hours worked drop substantially after age 45 for non-college educated households while they drop later for those that are college educated. This …gure, using cross-section data, is consistent with the …ndings of McGrattan and Rogerson (1998) regarding the life-cycle pro…les of hours worked for di¤erent cohorts.

Figure 6: Fraction of Hours Worked by the Household



2.4 The relationship between hourly wages and childbearing

In order to further assess the relationship between hourly wages and childbearing I perform the Logit estimations reported in Table V. First, I run a Logit estimation with childbearing as a dependent binary variable and hourly household wage as the independent variable, the results are reported in the …rst column of Table V. This exercise yields an estimate of ¡0:066, which implies a slope coe¢cient of ¡0:013 for the derivative of the probability of childbearing with respect to wages. Childbearing is more likely when wages are lower. The question remaining is whether this relationship is the result of life cycle e¤ects, namely childbearing mostly occurring at the beginning of household's lifetime, when given the age-pro…le of hourly earnings wages are lower.

Table V: Logit estimates of the relationship between wages and childbearing

	Total Sample	Total Sample	Non-College	College
Hourly wage	-0.066	0.0037	0.0024	0.0034
Slope	-0.013	0.00062	0.00037	0.00060
Std. Error	0.0032	0.0023	0.0040	0.0029
Age female	–	-0.044	-0.047	-0.040
Slope	–	-0.0073	-0.0074	-0.0071
Std. Error	–	0.0019	0.0027	0.0026

To control for age (i.e. timing of childbearing decisions) I run a Logit estimation with childbearing as a dependent binary variable and hourly household wage and age of female as independent variables, see the second column of Table V. Notice that this exercise implies that the sign of the coe¢cient on wages changes, yielding an estimate of 0:0037 for hourly wages, which implies a value of 0:00062 for the derivative of the probability of childbearing with respect to wages. The change in the sign of the wage coe¢cient is easily seen in Figure 4, where, for households older than 28 years old, wages are higher for those who have newborns than for those who don't, while for younger households there is no signi…cant di¤erence in wages. However, this positive relationship might be the result of di¤erences in educational attainment: college educated (higher wages) households have children later, see Figure 1.

Now, in order to further control for the level of educational attainment of the household, I subdivide the sample between college and non-college educated households. For the non-college subsample (column 3 of Table V) the coe¢cient on wages is even smaller, 0:00037 for the derivative coe¢cient. For the college subsample (column 4 of Table V) the derivative coe¢cient on wages is 0:00060. We observe how once educational attainment is taken into account, the relationship between wages and childbearing becomes even smaller, if not zero.

These results suggest that household's hourly wages are not signi…cantly correlated (or slightly positively, if any, given the standard errors reported) with childbearing once we control for timing of fertility decisions and the level of educational attainment.

This …ndings are consistent with the …ndings of Simon (1977), regarding the positive relationship between earnings and completed fertility once we control for age and educational levels. Wolpin (1984) …nds a positive but small relationship between income and childbearing, after controlling for age.

3 The Model

The objective is to construct a model that is capable of generating age-profiles of childbearing depending on educational status similar to those reported in Figure 1. Then, such a model will be tested in its ability to shed light on the empirical findings reported in the previous section and summarized in facts 1 to 4.

The economy is populated by a continuum of overlapping generations households, each of which is formed by a male and female adults and potentially children. Households live for a finite number of periods, J, retirement is compulsory at age j_r. The fertile period of a household is the first j^* periods.

There are two types of households depending on their level of educational attainment, denote them H, for High, and L, for Low. Let $\chi \in (0,1)$ denote the fraction of households with low educational level. The educational choice is not explicitly modelled in this environment, it is assumed that this decision has been made previously to age 18 (first period in the model). Acquiring a high level of education has a cost in terms of time needed during the first periods of life, but there is no monetary cost associated to it.[4]

Households derive utility from "adult equivalent consumption" (this will be discussed in detail in the parameterization section) within the household, leisure and family size. Therefore, altruism is not modelled in this environment. Having children is costly both in terms of resources, children reduce adult equivalent consumption, and time.

Labor productivity of household i, measured in terms of efficiency units of labor, is the product of a deterministic and a stochastic component. The deterministic age component ($\epsilon_{j,i}$) differs across age, j, and the level of educational attainment of household i. The stochastic idiosyncratic component (η_i), invariant across age but potentially different across educational groups, follows a finite state Markov process with stationary transition matrix $Q(\eta, \eta') = Prob(\eta_{t+1} = \eta' | \eta_t = \eta)$.

Markets are incomplete in the sense that insurance markets are assumed to be missing and there exists a nonnegativity constraint on households' asset position. Households can only insure against income uncertainty by trading a one-period uncontingent bond.

[4] Potentially, it would be very interesting to include those, especially if the objective is to endogeneize the educational choice.

The educational attainment of parents enters in the model in two ways. On the one hand parents with high educational level have to spend some of their time while young acquiring this higher skill level. On the other hand, highly educated households face a higher and steeper deterministic age profile of labor earnings. The specific shape of the age-earnings profile of households depending on educational attainment will be discussed later.

3.1 Timing of the model and of fertility decisions

I will consider one period in the model as two years and households live for 30 periods and retire in period 24. Every household is formed by a male and female adult. The fertile period is the first 10 periods. So, the model could be interpreted as a world where individuals become economically independent at age 18, they retire at age 64 and death occurs at age 78. I assume there is no uncertainty about length of lifetime. Upon retirement households receive a retirement pension financed through a pay-as-you-go social security system.

Every period households 1 (18 years old) through 10 (36 years old) decide whether to have one additional child next period or not. Thus, households with newborns range from ages 20 to 39.

Households with high educational level have to spend a fraction of their time during the first four periods of life acquiring skills.

When children turn 18 they leave the household of their parents and form a new household.

Explicitly, timing in the model regarding childbearing decisions works as follows:

Period 1 (18 years): 1st child decision
Period 2 (20 years): 1st child born with probability φ
⋮
Period 10 (36 years): Last child decision
Period 11 (38 years): 1st child turns 18 and leaves / Last child born
⋮
Period 20 (56 years): Last child turns 18 and leaves
⋮
Period 24 (64 years): Mandatory Retirement
⋮
Period 30 (76 years): Last period

3.2 The problem of the household

Households maximize expected utility at the initial period, choosing contingent plans for household consumption, hours worked, and when and how many children to have. The fertility decision is modelled so that every period during the fertile years the household decides whether to have one additional child next period or not. There is uncertainty associated to that decision in the sense that, conditional on having decided to have a newborn next period, this event will happen with probability $\varphi \in (0, 1)$; I will consider φ as a fixed parameter constant across households and age. However, there is no uncertainty if the household decides not to have a newborn. Let j^* denote the last fertile year of the household, which is known with certainty, i.e. $\varphi = 0$, for all $j > j^*$.

Acquiring a high level of education is time consuming and having children is costly both in terms of time and resources once they are born.

Preferences of a household depend on adult equivalent consumption, leisure and family size, according to the following functional form:

$$\sum_{j=1}^{J} \beta^{j-1} U(c_j, l_j, n_{h,j}, n_j) \tag{1}$$

$$\begin{aligned} U(c, l, n_h, n) &= (1-\mu)\frac{1}{1-\sigma_1}\left[\left(\frac{c}{g(n_h)}\right)^{\gamma}(1 - l - h(n_h) - \chi\lambda)^{1-\gamma}\right]^{1-\sigma_1} + \\ &\quad \mu\frac{1}{1-\sigma_2}(2+n)^{1-\sigma_2} \end{aligned} \tag{2}$$

where c denotes total household consumption, l are hours worked, n_h is the number of children staying at home and n is the total number of children regardless of whether they are still at home or not. The function $g(\cdot)$ is used to transform units of household consumption into units of adult equivalent consumption, depending on the number of children at home. The function $h(\cdot)$ determines the time cost of children staying at home, which will be decreasing in age.

The constant λ denotes the amount of time needed to acquire a high level of education, and χ is an indicator function that takes value 1 for the first four periods of a household acquiring skills and zero otherwise.

The functional form proposed implies that preferences depend additively on the consumption-leisure bundle with the standard CRRA specification, and on family size (the term $2 + n$) with a curvature parameter given by σ_2. The parameter μ determines the weight that households put on family size in their preferences.

The problem of the household can be written recursively. Households are indexed by: i, type (high or low education); a, asset position; η, labor productivity status; j, age; and z^j, history of past fertility decisions. The element z^j is a vector of zeros and ones, depending on whether the household had a child or not at every age from 2 to j. This element keeps track of the number and age of children in the household. $\Phi_t(i; a; \eta; j; z^j)$ denotes the measure of households of type $(i; a; \eta; j; z^j)$ at time t.

Then, the problem of a household can be written as follows. Households choose consumption, c, assets next period, a', hours worked, l, and whether to have a child next period or not, d, to solve the following programming problem:

$$
\begin{aligned}
v_t(i; a; \eta; j; z^j) = \max_{c;a';l;d} \{ & U(c; l; z^j) + \\
& + \beta \int v_{t+1}(i; a'; \eta'; j+1; z^{j+1}) Q(\eta'; d\eta') \}
\end{aligned} \tag{3}
$$

subject to:

$$
\begin{aligned}
c + a' &= (1 - \tau_t) w_t \epsilon_{j;i} \eta l + (1 + r_t) a \qquad \text{if } j < j_r \\
c + a' &= SS_t + (1 + r_t) a; \qquad \text{if } j \geq j_r
\end{aligned} \tag{4}
$$

$$
a' \geq 0; c \geq 0 \tag{5}
$$

$$
\begin{aligned}
l &\in (0; 1) \\
l &\in (0; 1 - \mu), \text{ if } i = H \text{ and } j \leq 4
\end{aligned} \tag{6}
$$

$$
\Phi_{t+1} = M(\Phi_t) \tag{7}
$$

where

$$
d = \begin{cases} 1 & \text{, if decide to have a newborn and } j < j^* \\ 0 & \text{otherwise} \end{cases} \tag{8}
$$

It is understood that $\epsilon_{j,i}$ is equal to zero whenever the household is retired.

Individual households rent their efficiency units of labor and their assets to firms, and receive in exchange competitive prices w_t and r_t, that depend on the aggregate measure of households, Φ_t. Upon retirement households receive a retirement pension, SS_t, financed through a pay-as-you-go social security system financed with labor taxes, denoted by τ_t. Households maximize taking prices and the aggregate law of motion M as given.

3.3 Technology

I assume that the aggregate production frontier in this economy is given by a Cobb-Douglas production function. Therefore, the aggregate resource constraint is:

$$C_t + K_{t+1} - (1 - \delta)K_t = K_t^{\theta} N_t^{1-\theta} \tag{9}$$

where K_t is aggregate capital stock, N_t is aggregate number of efficiency units of labor, $\delta \in (0, 1)$ denotes the depreciation rate and $\theta \in (0, 1)$.

4 Computation and Parameterization

The model is computed for its steady-state equilibrium and compared to the results obtained from the empirical evidence.

The algorithm used to compute the steady-state equilibrium works as follows:

- Choose an initial guess on prices.
- Compute working backwards the value functions and policy functions from the household problem.
- Using the policy functions compute growth rate of population and the stationary population structure implied by it.
- Given the population structure and the policy functions, market clearing yields new guess for prices.
- Iterate until convergence in prices and growth rate of population is reached.

The model has been calibrated to the USA economy. Therefore, as a benchmark I take the model with a pay-as-you-go Social Security system; workers contribute 10.7% of their labor income to the social security system, this implies a replacement rate of 45.9% (retirement pensions equal to less than half of the average labor earnings of the same period). I choose this benchmark because it replicates the system in the USA, where the Old-Age and Survivors Insurance (OASI) rate is 10.7%.[5]

The fraction of low education households is set to $\psi = 0.6$, equal to the average found in the PSID sample.

The preference parameters are reported in Table VI. The key element in the calibration is the choice of values for σ_1, σ_2 and μ, that has been done such that the model is consistent with completed fertility and timing of fertility as observed in the data. It is important to note that the smaller the risk aversion, σ_1, the larger is the difference in completed fertility between the high and low education groups, so that σ_1 is chosen to match the gap in completed fertility between those two groups. On the other hand, the parameter σ_2 determines the shape of the age profile of fertility. High σ_2 (low intertemporal elasticity of substitution regarding family size) implies fertility more concentrated at the beginning of household's lifetime, so that family size would be more constant over the life cycle. Finally, the parameter μ determines the levels of completed fertility.

Table VI: Preference Parameters

Parameter	Value
σ_1	2.60
β	0.96
γ	0.35
λ	0.20
μ	0.75
σ_2	1.25

Those parameters together imply that completed fertility for low-education households is 2.45 (2.46 in the data), and 1.99 for high-education households (1.97 in the data). It is remarkable how the value of σ_1 chosen to match the

[5] Total Social Security taxes in the USA are 15.3%, but those include also Medicare and Disability Insurance. For a specific treatment of Social Security and the effects of its potential reform, see Conesa and Krueger (1999).

difference in completed fertility between educational levels is in the range of values obtained in the business cycle literature.

The value chosen for the yearly discount factor is 0.98, which implies $\beta = 0.9604$ given the choice of length of a period. Together with σ_1, it implies that in the steady state the yearly interest rate is 6%, the yearly capital-output ratio is 3.0 and (given the choice of δ) the yearly investment-output ratio is 18%. The share of consumption in the utility function is set to $\gamma = 0.35$, so that in the steady state households will spend on average 26% of their discretionary time working, as we observe in the PSID data. The fraction of time spent acquiring skills for the first four periods of households with high level of education is set to $\lambda = 0.2$, i.e. we are considering that acquiring skills is equivalent to a part-time job for each of the adults in the household in terms of time requirement.

The function $g(\cdot)$ is taken to be $g(n_h) = 1.7 + 0.5 \cdot n_h$. This choice follows the adult equivalence Oxford-scale, that was later adopted by the OECD and Eurostat. This is an additive scale that weights the first adult as 1, the second as 0.7 and children (below 18) as 0.5. For a discusion of this and other equivalence scales, see Van Praag and Warnaar (1997).

The function $h(\cdot)$ is set so that the time requirement for a newborn is 0.2 (roughly the time requirement of a part-time job for each of the adults in the household) and it is linearly decreasing in the age of children until 0 for an 18 year old (age at which children leave home). This time requirement function is consistent with the estimates reported by Browning (1992).[6]

The probability of having a newborn at period t conditional on having chosen to do so in period $t - 1$, is set to $\varphi = 0.85$.

For technology parameters, reported in Table VII, I chose standard values in the business cycle literature. Namely, a share of labor in output of 64% and a yearly depreciation rate of 6%.

Table VII: Technology Parameters

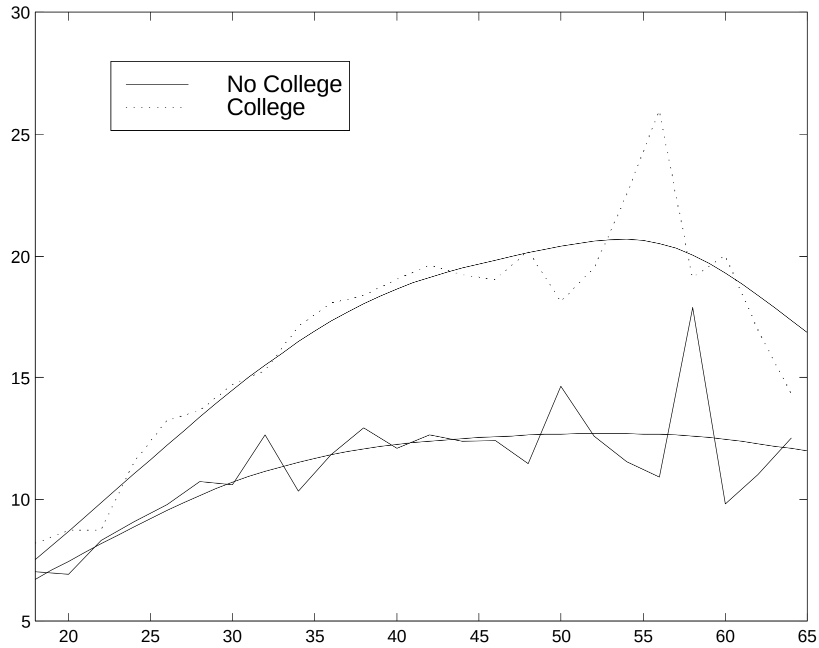
Parameter	Value
θ	0.36
δ	0.1136

The deterministic age profiles of labor earnings for both low and high level of education households are taken from the PSID data. Figure 7 reports labor

[6] Figure 3 in Browning (1992) displays the time requirement only for the female adult, and the estimates are themselves based on econometric estimates by Hotz and Miller (1988) considering female time allocation only.

income per hour worked for both college and non-college households. Those series have been …ltered and the trend component has been used for the model computation. Notice that average wages of households with high level of educational attainment are higher, and also its age-pro…le is steeper, than the age-pro…le found for households with low level of educational attainment. It is important to bear in mind that by dealing with the household as a uni…ed decision unit in the way the model does, the opportunity cost of childbearing will be the average hourly wage in the household and not the hourly wage of the female.

Figure 7: Age Pro…le of Hourly Wages



For the stochastic component of labor earnings I follow Hubbard et al. (1994). They use PSID data to estimate the idiosyncratic component of (the log of) labor earnings, for di¤erent educational groups. They …nd that autocorrelation of earnings is roughly 95% for both low and high educated households, and that the variance of the idiosyncratic component of low educated households is twice that of college educated households. Then, I take their estimates and approximate this autoregressive process by a …ve state Markov chain. In order to do so I use the procedure described in Tauchen and Hussey (1991), resulting in …ve values for the productivity status and the correspondent transition matrix, reported in Table VIII and Table IX respectively.

Table VIII: Individual Productivity Parameters

Parameter	Low Edu.	High Edu.
ϵ_1	0.6097	0.6967
ϵ_2	0.7910	0.8424
ϵ_3	1.0000	1.0000
ϵ_4	1.2647	1.1870
ϵ_5	1.6402	1.4353

Table IX: Yearly Transition Matrix

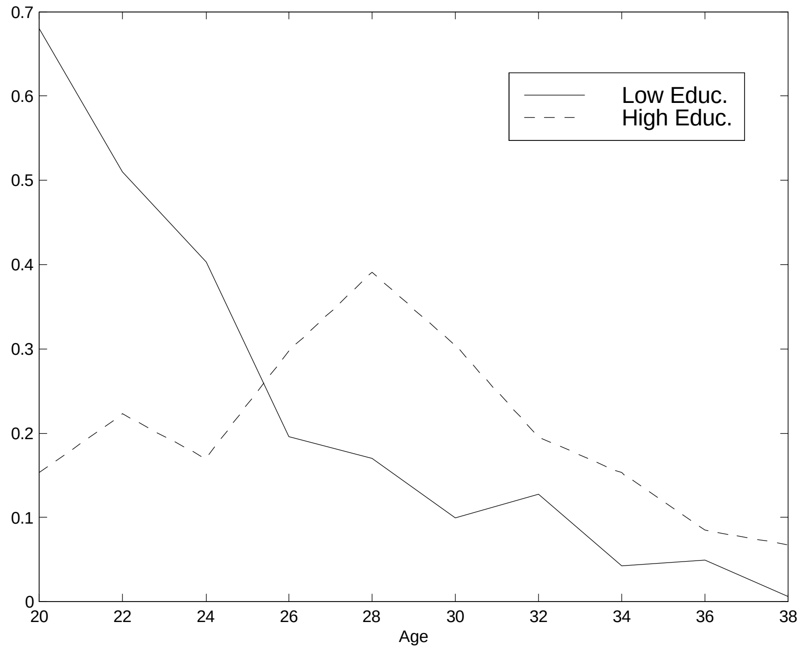
$$Q(\epsilon;\epsilon') = \begin{bmatrix} 0:7376 & 0:2473 & 0:0150 & 0:0002 & 0:0000 \\ & 0:5555 & 0:2328 & 0:0169 & 0:0001 \\ & & 0:5333 & 0:2221 & 0:0113 \\ & & & 0:5555 & 0:1947 \\ & & & & 0:7376 \end{bmatrix}$$

The …rst row in the transition matrix is the probability of realizing next period shocks 1 through 5 conditional on today's realization of shock 1. Given that I chose one period in the model to be two years and that the estimates of Hubbard et al. (1998) are yearly data, the transition matrix has to be raised to the power of two to be consistent with the choice of model period length.

5 Results

Figure 8 shows the main results of the model economy in terms of timing of childbearing, as compared to the empirical …ndings from Figure 1. The parameter σ_2 was chosen to generate a decreasing age-pro…le of birth rates for low educated households, while for highly educated households it generates a hump shape, as observed in the data. However, low educated households tend to concentrate more of their childbearing at early periods in comparison with the data. Completed fertility for low-education households is 2:45 (2:46 in the data), and 1:99 for high-education households (1:97 in the data).

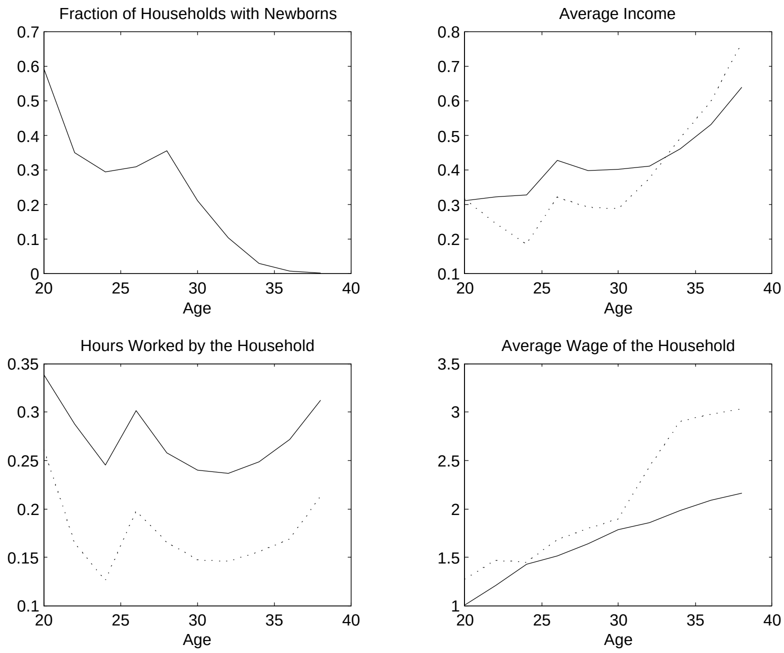
Figure 8: Age-Education Birth Rates: Model Economy



The model replicates the following empirical fact: for younger households wages do not di¤er substantially between households that have newborns and households who do not; however, for older households, those with newborns have on average higher wages than those without them. See Figure 9 as compared to Figure 4. Also, notice that average income is smaller for young households with newborns than for those without newborns, while the reverse is true for older households. Low-educated households (with low wages) would choose to have children earlier in their lifetime, but some "lucky" highly educated households would choose to have children earlier too. This e¤ect, together with the fact that the di¤erence between college and non-college wages is increasing in age, results in no signi…cant di¤erence in wages between those who have newborns earlier in their lifetime and those who do not. Highly educated households (with higher and steeper age pro…le of wages), on the contrary, will have children later on average, so that households with newborns will have substantially higher wages than those without them. We observe positive relationship between childbearing and wages as we see in the data once we take into account di¤erences in timing.

Figure 9: Comparison of Households with and without Newborns: Model Economy

With Newborns - - - - - Without Newborns ———

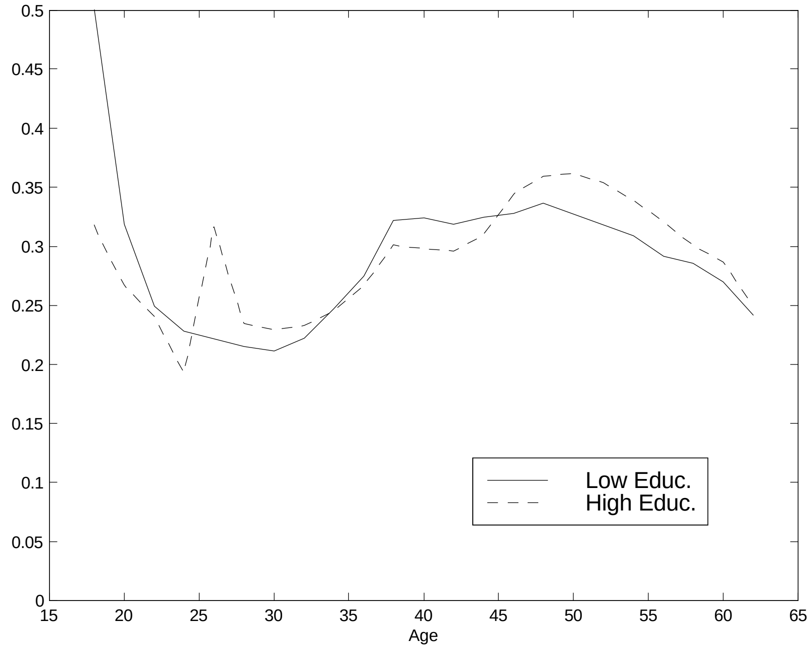


However, the model does not display the fact that older households experience a smaller decrease in hours worked due to childbearing than younger ones. Notice also that in the model hours worked by those who do not have newborns are roughly 30% higher, while in the data this di¤erence is only of 15%.

The life cycle pro…le of hours worked depending on level of educational attainment of parents is shown in Figure 10, as compared to its empirical counterpart of Figure 6.[7] The model fails to display the fact observed in the data that college-educated households work on average signi…cantly more than non-college ones, and it also fails in displaying such a clear hump-shape as observed in the data.

[7] The hump-shaped life cycle pattern of hours worked, both for male and female individuals, has been documented in McGrattan and Rogerson (1998). They focus on how this pattern has changed over time and mention: "several factors that may be relevant in accounting for these reallocations: changes in Social Security bene…ts, fertility rates, and family structure."

Figure 10: Fraction of Hours Worked: Model Economy



Essentially, the model generates timing of fertility and a relationship between wages and childbearing (and income and childbearing) similar to those found in the data. Moreover, conditional on educational status and age, wages are slightly positively related to childbearing as we observed in the data.

5.1 A closer look at the relationship between wages and childbearing

In order to further assess the relationship between wages and childbearing implied by the model I perform the following exercise. I generate by Montecarlo simulation a random sample of households from the model (of equal size to that of the PSID sample) and then perform on it exactly the same type of exercise I did on the PSID sample to explore the relationship between wages and childbearing and the e¤ects of timing on it. Table X reports this results (those should be compared with its empirical counterpart reported in Table V).

Table X: Logit estimates of the relationship between wages and childbearing. Model Economy

	Total Sample	Total Sample	Low Educ.	High Educ.
Hourly wage	-0.1027	0.038	0.044	0.030
Slope	-0.018	0.0056	0.0064	0.0045
Age female	–	-0.0704	-0.071	-0.067
Slope	–	-0.0102	-0.0103	-0.0099

It is remarkable how closely similar is the coefficient regarding the relationship between childbearing and wages generated by the model (-0.10) as compared to the one obtained from the PSID sample (-0.07). As in the data, once we control for age of the female the coefficient on wages becomes positive and very close to zero. However, the slope coefficients corresponding to wages are higher in the model generated data than in the PSID sample.

Overall, the main result seems very robust: hourly wages are negatively correlated with the probability of childbearing, but once we control for age (i.e. timing of fertility decisions) the relationship between wages and childbearing becomes positive and substantially smaller. The model, however, implies a larger impact of wages on childbearing than observed in the data.

5.2 The role of income uncertainty

In order to assess the effects of labor earnings uncertainty over fertility rates and timing of childbearing I perform the following experiment. I fix prices at the level of the benchmark economy (6% for the interest rate) and compute optimal behavior of households where the transition matrix for the stochastic process of labor productivity is set equal to the identity matrix.

As a result we obtain that both low and high educated households will have an average of 2.24 children over their lifetime, so that labor earnings uncertainty increases (decreases) completed fertility of households with a low (high) level of educational attainment with respect to an ex-ante average optimal family size of 2.24 children. Moreover, yearly population growth rate would be 0.43%; roughly the same as in the uncertainty case.

The reasons for this pattern to arise are that in an environment with uncertainty where households cannot borrow on future income, it is optimal to have children when the stochastic component is more favorable (remember that in this environment childbearing is positively correlated with hourly wages conditioning on age). If households want to have children later in their lifetime, waiting for "the right time" for childbearing reduces fertility rates.

Households with a stream of bad realizations will decide to have less children than their ex-ante optimal family size. On the other hand, we have seen that the optimal family size for the average low-education household is 2:24 children and to have them early; uncertainty does not a¤ect substantially childbearing decisions at the beginning of their lifetime, but later in the reproductive period some households might have been "lucky" enough as to decide to have an additional child, increasing their average fertility.

Therefore, in this framework it is the asymmetric e¤ect of earnings uncertainty, depending on timing of childbearing, what generates that highly educated (higher wages) households have on average less children than those households with low level of educational attainment. The key for this result to arise is that children are treated as an irreversible consumption durable, and irreversibility is key in the presence of earnings uncertainty.

6 Conclusions

This paper focuses on the study of household's decisions regarding timing of fertility, depending on the level of educational attainment of parents. It is shown how the recent evolution in total fertility rates observed in developed countries could be the result of a transition from an early childbearing regime to a late childbearing regime, due to the increase in level of educational attainment of females. Measures of total fertility rates might be misleading in an environment with important changes in timing of childbearing, even if completed fertility does not change substantially. Then, the objective is to understand the determinants of timing of fertility decisions and its relationship with educational attainment.

The main empirical …ndings from a cross section of households in the PSID data base is that the relationship between hourly wages and childbearing is slightly positive (if not zero) once we condition for age of the female in the household. These …ndings suggest that in order to understand the relationship between wages and fertility the timing of childbearing decision might be an important factor, in particular because it implies a di¤erential behavior between households depending on their level of educational attainment. I show how a general equilibrium overlapping generations model with idiosyncratic uncertainty can be calibrated to match the timing of fertility facts. In the model timing of fertility decisions are explicitly addressed, in the sense that childbearing is modelled as a sequential binary decision. Such a model is consistent with the …ndings regarding the relationship between wages and childbearing.

The role of labor earnings uncertainty is important in this framework. In fact, it has asymmetric e¤ects on the fertility of households depending on their educational level, increasing completed fertility for households with low education and decreasing it for households with high education. Households with low level of educational attainment have children earlier in their lifetime, the existence of earnings uncertainty does not change their childbearing decisions at the beginning of their reproductive period. However, towards the end of their reproductive period some households have experienced a high sequence of stochastic realizations of labor earnings and might decide to have an additional child. The contrary happens to highly educated households, they tend to postpone childbearing, and given that some households might have experienced a low sequence of stochastic realizations of labor earnings they would decide to reduce their ex-ante optimal family size. This happens in an environment where absent uncertainty optimal family size is the same for both household types. The key for the asymmetric e¤ects of uncertainty to arise is the di¤erence in timing of fertility together with irreversibility of childbearing decisions. It is in this respect that this approach departs from previous explanations in the literature of the negative relationship between earnings and completed fertility.

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